

TITLE

Transmission Lubricating Compositions with Improved Performance, Contain-
ing Acid/Polyamine Condensation Product

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FIELD OF INVENTION

[0001] The present invention relates to an oil of lubricating viscosity containing the condensation product of a polyamine and an acid, a hydrocarbyl phosphite and boron containing compounds. The composition has improved wear properties. The composition can be used in automatic transmission fluids.

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BACKGROUND OF THE INVENTION

[0002] It is known to add various additives to an oil of lubricating viscosity for automatic transmission fluids (hereinafter referred to as ATF) to improve resistance to wear, decrease anti-shudder properties and provide the appropriate friction properties. Friction properties of an ATF have to be balanced to provide
15 high dynamic torque for efficient clutch engagement capacity and high static friction for good clutch holding. The ATF also has to provide a positive friction versus speed curve slope for good anti-shudder durability. These competing requirements are difficult to balance. In addition antiwear properties need to be sufficient for gear durability.

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[0003] In an effort to overcome these issues vehicle manufacturers have defined specifications; for example, The Ford Motor Company have the MER-CON®V specification. These specifications highlight a number of tests that ATF's and other lubricating oil compositions should satisfy. For ATF's to satisfy wear requirements, to decrease anti-shudder properties and to have the
25 appropriate friction properties, important tests include "The Ford/Greening Low Speed Friction Test", "The Timken Wear Test" and "The Ford Clutch Friction Durability Test." Many known lubricating oil compositions for ATF systems successfully pass one or two of the named tests above. From an automotive manufacturers perspective it would be desirable to have one composition capable of passing all three of the above named tests.

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[0004] US Patent 6,482,777 discloses a lubricating composition for a transmission package containing at least one saturated fatty phosphate ester or salt

and optionally either at least one fatty acid imidazoline or the reaction product of a fatty acid and polyalkylene polyamine and/or a borated dispersant, wherein the lubricating composition is free of saturated fatty phosphites. The composition exhibits improved friction properties and optionally improved thermal stability.

[0005] US 5,759,965 discloses the combination of boron containing over-based materials, borated epoxides, borated dispersants, a variety of phosphorus acid esters and derivatives thereof and an oil of lubricating viscosity.

[0006] US 6,528,458 disclose the combination of 2,5-dimercapto-1,3,4-thiadiazole, imidazoline, borated epoxides and short chain phosphites and, in a different example, borated dispersants.

[0007] US Patent 6,103,673 discloses a composition containing at least 0.1 wt% of an overbased metal salt and contributing 0.5 to 10 total base number (TBN) to the composition, at least 0.1 wt% of a phosphorus compound, 0.1 to 0.25 wt% of a combination of friction modifiers selected from zinc salts of fatty acids with at least 10 carbon atoms, hydrocarbyl imidazolines containing at least 12 carbon atoms in the hydrocarbyl group and borated epoxides.

[0008] US Patent application 2002/0151441 discloses an automatic transmission fluid containing at least 0.1 wt% of a metal detergent, a dispersant, a mixture of at least two friction modifiers and a base oil. The composition exhibits anti-shudder properties and friction durability.

[0009] It would be desirable to have compositions with improved wear resistance. The invention further provides anti-shudder properties and the appropriate friction properties. The invention further provides compositions suitable for use in a variety of automatic transmission fluids.

SUMMARY OF THE INVENTION

[0010] The present invention provides a composition comprising:

- (a) a hydrocarbyl phosphite;
- (b) a condensation product of a fatty acid with a polyamine;
- (c) a borate ester;
- (d) a borated dispersant; and
- (e) an oil of lubricating viscosity.

[0011] The invention further provides a process for preparing a composition mixing:

- (a) a hydrocarbyl phosphite;
- (b) a condensation product of a fatty acid with a polyamine;
- 5 (c) a borate ester;
- (d) a borated dispersant; and
- (e) an oil of lubricating viscosity.

[0012] The invention further provides compositions with improved wear resistance, improved anti-shudder properties, and the appropriate friction durability. The invention further provides compositions suitable for use in a variety of power transmissions, especially automatic transmission fluids.

DETAILED DESCRIPTION OF THE INVENTION

[0013] As used herein, the term "hydrocarbyl substituent" or "hydrocarbyl group" is used in its ordinary sense, which is well-known to those skilled in the art. Specifically, it refers to a group having a carbon atom directly attached to the remainder of the molecule and having predominantly hydrocarbon character. Examples of hydrocarbyl groups include:

[0014] hydrocarbon substituents, that is, aliphatic (e.g., alkyl or alkenyl), alicyclic (e.g., cycloalkyl, cycloalkenyl) substituents, and aromatic-, aliphatic-, and alicyclic-substituted aromatic substituents, as well as cyclic substituents wherein the ring is completed through another portion of the molecule (e.g., two substituents together form a ring);

[0015] substituted hydrocarbon substituents, that is, substituents containing non-hydrocarbon groups which, in the context of this invention, do not alter the predominantly hydrocarbon nature of the substituent (e.g., halo (especially chloro and fluoro), hydroxy, alkoxy, mercapto, alkylmercapto, nitro, nitroso, and sulfoxy);

[0016] hetero substituents, that is, substituents which, while having a predominantly hydrocarbon character, in the context of this invention, contain other than carbon in a ring or chain otherwise composed of carbon atoms. Heteroatoms include sulfur, oxygen, nitrogen, and encompass substituents as pyridyl, furyl, thienyl and imidazolyl. In general, no more than two, preferably no more

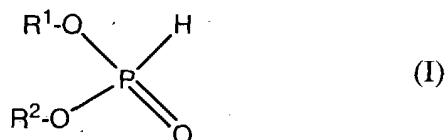
than one, non-hydrocarbon substituent will be present for every ten carbon atoms in the hydrocarbyl group; typically, there will be no non-hydrocarbon substituents in the hydrocarbyl group.

[0017] The present invention provides a composition comprising:

- 5 (a) a hydrocarbyl phosphite;
- (b) the condensation product of at least one fatty acid with a polyamine;
- (c) a borate ester;
- (d) a borated dispersant; and
- 10 (e) an oil of lubricating viscosity.

10 Hydrocarbyl Phosphite

[0018] The hydrocarbyl phosphite of the invention can be represented by the formula:



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wherein at least one of R^1 and R^2 is a hydrocarbyl group containing at least 8 carbon atoms and the other can be hydrogen or a hydrocarbyl group; preferably both R^1 and R^2 are hydrocarbyl groups. The hydrocarbyl groups can be alkyl, cycloalkyl, aryl, acyclic or mixtures thereof. The hydrocarbyl group can be
20 alkyl with 8 to 40, preferably 10 to about 35, more preferably 12 to 30, even more preferably 13 to 25, and even more preferably 14 to 20 carbon atoms.

[0019] Alkyl groups can be linear or branched, preferably linear, and saturated or unsaturated, preferably saturated. Examples of alkyl groups suitable for R^1 and R^2 include octyl, 2-ethylhexyl, nonyl, decyl, undecyl, dodecyl, tridecyl,
25 tetradecyl, pentadecyl, hexadecyl, heptadecyl, octadecyl, octadecenyl, nonodecyl, eicosyl or mixtures thereof. In one embodiment R^1 and R^2 each have 16 to 18 carbon atoms.

[0020] The hydrocarbyl phosphite is typically present at 0.01 to 5, preferably 0.03 to 1, and more preferably 0.05 to 0.7 and even more preferably 0.1 to 0.4
30 weight percent of the lubricating oil composition.

The Condensation Product of a Fatty Acid with a Polyamine

5 [0021] The condensation of a fatty acid and a polyamine of the invention typically result in the formation of at least one compound selected from hydrocarbyl amides, hydrocarbyl imidazolines and mixtures thereof. In one embodiment the condensation products are hydrocarbyl imidazolines. In one embodiment the condensation products are hydrocarbyl amides. In one embodiment the condensation products are mixtures of hydrocarbyl imidazolines and hydrocarbyl amides. Preferably the condensation product is mixtures of hydrocarbyl imidazolines and hydrocarbyl amides.

10 [0022] The fatty acid of the invention can be derived from a hydrocarbyl carboxylic acid. The hydrocarbyl group can be alkyl, cycloalkyl, or aryl, although alkyl is preferred, and the hydrocarbyl groups can be linear or branched. Typically the fatty acid contains 8 or more, preferably 10 or more, more preferably 13 or more and even more preferably 14 or more carbon atoms (including
15 the carbon of the carboxy group). Typically the fatty acid contains 8 to 30, preferably 12 to 24 and even more preferably 16 to 18 carbon atoms. Other suitable carboxylic acids can include the polycarboxylic acids or carboxylic acids or anhydrides having from 2 to 4 carbonyl groups, preferably 2. The polycarboxylic acids can include succinic acids and anhydrides and Diels-Alder
20 reaction products of unsaturated monocarboxylic acids with unsaturated carboxylic acids (such as acrylic, methacrylic, maleic, fumaric, crotonic and itaconic acids). Preferably, the fatty carboxylic acids are fatty monocarboxylic acids containing 8 to 30, preferably 10 to 26 and even more preferably 12 to 24 carbon atoms.

25 [0023] Examples of suitable fatty acids can include caprylic acid, capric acid, lauric acid, myristic acid, palmitic acid, stearic acid, eicosic acid and, tall oil acids. Preferably the fatty acid is stearic acid, which can be used alone or in combination with other fatty acids.

[0024] The polyamines of the invention can be acyclic or cyclic, preferably
30 acyclic; and linear or branched, preferably linear.

[0025] In one embodiment the polyamines can be alkylenepolyamines selected from the group consisting of ethylenepolyamines, propylenepoly-

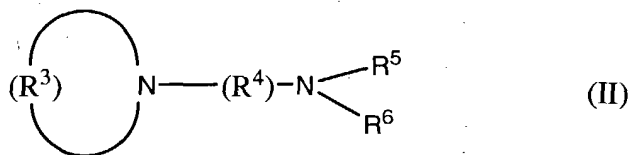
amines, butylenepolyamines and mixtures thereof. Examples of propylenepolyamines can include propylenediamine and dipropylenetriamine.

[0026] Particularly preferred ethylenepolyamines are selected from the group consisting of ethylenediamine, diethylenetriamine, triethylenetetramine, tetra-
5 ethylenepentamine, pentaethylenehexamine, N-(2-aminoethyl)-N'-[2-[(2-aminoethyl)amino]ethyl]-1,2-ethanediamine, polyamine still bottoms and mixtures thereof.

[0027] In one embodiment the polyamines can be α,β -diaminoalkanes. Suitable α,β -diaminoalkanes can include diaminopropanes, diaminobutanes or
10 mixtures thereof. Specific diaminoalkanes are selected from the group consisting of N-(2-aminoethyl)-1,3-propane diamine, 3,3'-diamino-N-methyldipropylamine, tris(2-aminoethyl)amine, N,N-bis(3-aminopropyl)-1,3-propane diamine, N,N'-1,2-ethanediylbis-(1,3-propane diamine) and mixtures thereof.

[0028] In one embodiment other polyamines can include di-(trimethylene)triamine, piperazine, diaminocyclohexanes and mixtures thereof.

[0029] In one embodiment the polyamine can be cyclic and can include, but are not limited to, compounds that are represented by the formula:



20 wherein R^3 represents a carbocyclic or heterocyclic group containing atoms bonded to form mono- or poly- nuclear rings; and the atoms are selected from the group consisting of carbon, oxygen, nitrogen, phosphorus and mixtures thereof. Preferably R^3 can be atoms selected from the group consisting of
25 carbon, oxygen, nitrogen and mixtures thereof.

[0030] The mononuclear cyclic structure typically contains 5 to 8 atoms and preferably 6 to 7 atoms. The polynuclear cyclic structure contains 8 to 16 and preferably 10 to 12 atoms. In formula (II), R^3 can contain 4 to 15, preferably 5

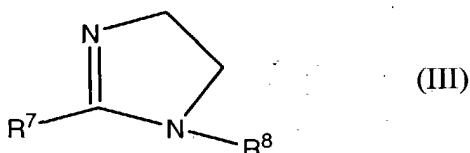
to 11, more preferably 5 to 8 atoms. The cyclic ring can be aromatic, non-aromatic or mixtures thereof, although non-aromatic is preferred.

[0031] R^4 can be a hydrocarbyl group, typically an alkyl or alkenyl group containing 1 to 8, preferably 1 to 6, and even more preferably 2 to 5 carbon atoms. The alkyl or alkenyl group can be substituted, unsubstituted, branched, unbranched alkylaryl, cycloalkyl or mixtures thereof. Suitable examples of R^4 can include ethyl, propyl, butyl and pentyl. Preferably R^4 is ethyl, propyl or mixtures thereof.

[0032] R^5 and R^6 can be hydrogen or hydrocarbyl; preferably at least one, and even more preferably both of R^5 and R^6 are hydrogen. When R^5 and R^6 are hydrocarbyl, the number of carbon atoms present in each of R^5 and R^6 is independently is in the range from 1 to 8, preferably 1 to 5 and even more preferably 1 to 3. Suitable examples of hydrocarbyl groups can include methyl, ethyl, propyl, butyl and pentyl.

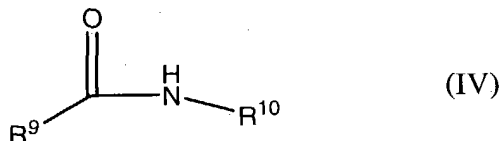
[0033] Examples of suitable cyclic polyamines include 4-(3-aminopropyl) morpholine, 4-(3-aminoethyl) morpholine or mixtures thereof. Preferably the cyclic amine is 4-(3-aminopropyl) morpholine, which, may be used alone or in combination with other polyamines.

[0034] Typically the hydrocarbyl imidazolines formed by a condensation product of a fatty acid with a polyamine can be represented by the formula:



wherein R^7 can be a hydrocarbyl group, preferably a linear or branched alkyl group, preferably linear; and the hydrocarbyl group can be saturated or unsaturated, preferably saturated. Typically the hydrocarbyl group R^7 can contain 8 or more, preferably 11 or more, preferably 14 or more and more preferably 16 or more carbon atoms. For example the hydrocarbyl group can contain 10 to 30, preferably 12 to 24 and more preferably 16 to 18 carbon atoms. In one embodiment the hydrocarbyl group contains 17 carbon atoms. R^8 can be is a hydrocarbyl group or a substituted hydrocarbyl group. In one embodiment, R^8 is derived from alkylenepolyamines discussed above.

[0035] Typically the hydrocarbyl amides formed by a condensation product of a fatty acid with a polyamine can be represented by the formula:



wherein R^9 can be a hydrocarbyl group of the type defined for R^7 above. R^{10} can be hydrogen, a hydrocarbyl group or a substituted hydrocarbyl group. In one embodiment, R^{10} is derived from alkylene polyamines discussed above.

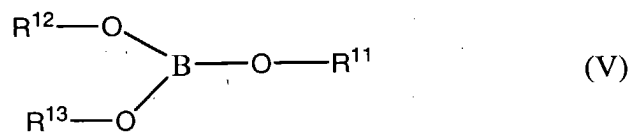
[0036] The condensation product of a fatty acid and a polyamine is typically present at 0.01 to 3, preferably 0.03 to 1, and more preferably 0.05 to 0.6 and even more preferably 0.07 to 0.3 weight percent of the lubricating oil composition.

Borate Ester

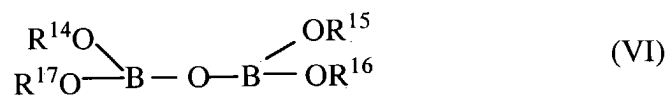
[0037] The invention further contains a borate ester. The borate ester can be prepared by the reaction of a boron compound and at least one compound selected from epoxy compounds, halohydrin compounds, epihalohydrin compounds, alcohols and mixtures thereof. Typically the alcohols include monohydric alcohols, dihydric alcohols, trihydric alcohols or higher alcohols. Hereinafter "epoxy compound or equivalent" is used when referring to "at least one compound selected from epoxy compounds, halohydrin compounds, epihalohydrin compounds, alcohols and mixtures thereof."

[0038] Boron compounds suitable for preparing the borate ester include the various forms selected from the group consisting of boric acid (including metaboric acid, HBO_2 , orthoboric acid, H_3BO_3 , and tetraboric acid, $\text{H}_2\text{B}_4\text{O}_7$), boric oxide, boron trioxide and alkyl borates. The borate ester can also be prepared from boron halides.

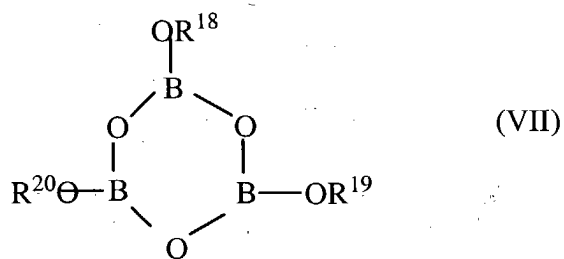
[0039] The borate ester formed by the reaction of a boron compound and an epoxy compound or equivalent can be represented by at least one formula selected from:



or

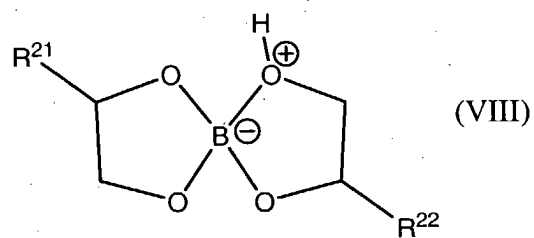


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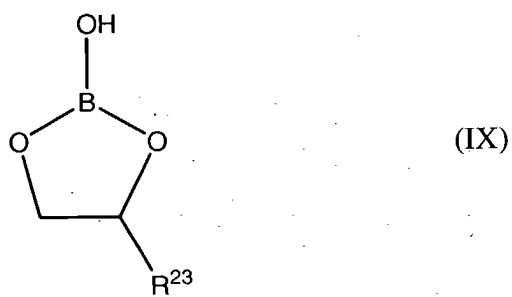


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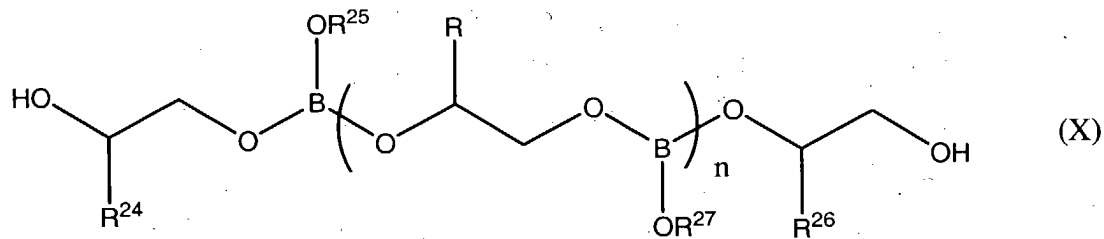


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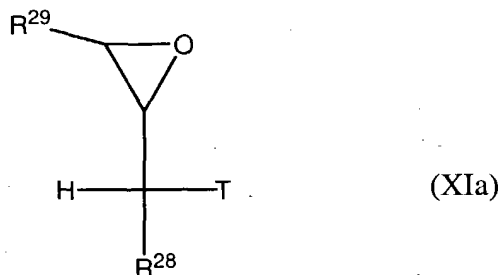


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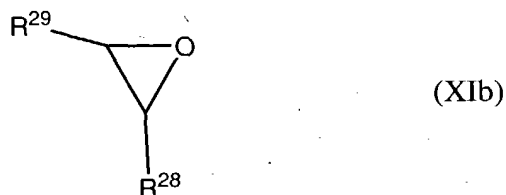
or



- wherein R^{11} , R^{12} and R^{13} can be hydrogen or hydrocarbyl groups provided at least one, preferably at least two of R^{11} , R^{12} and R^{13} are hydrocarbyl groups. In one embodiment, R^{11} is a hydrocarbyl group; and R^{12} and R^{13} are hydrogen. In one embodiment, R^{11} and R^{12} are hydrocarbyl groups and R^{13} is hydrogen. In one embodiment R^{11} , R^{12} and R^{13} are all hydrocarbyl groups. The hydrocarbyl groups can be alkyl, aryl or cycloalkyl when any 2 adjacent R groups are connected in a ring. When alkyl, the group can be saturated or unsaturated, unsaturated being preferred. In one embodiment the hydrocarbyl group is cyclic. In one embodiment the hydrocarbyl groups are mixtures of alkyl and cycloalkyl.
- 10 [0040] Typically there is no upper limit on the number of carbon atoms, but a practical limit is 500, preferably 400, more preferably 200, even more preferably 100 or 60. For example the number of carbon atoms present in R^{11} , R^{12} and R^{13} can be 1 to 60, preferably 1 to 40 and more preferably 1 to 30 carbon atoms, provided the total number of carbon atoms in R^{11} , R^{12} and R^{13} is 9 or more, preferably 10 or more, more preferably 12 or more or 14 or more.
- 15 [0041] In one embodiment R^{11} , R^{12} and R^{13} are all hydrocarbyl groups containing 1 to 30 carbon atoms, provided the total number of carbon atoms in R^{11} , R^{12} and R^{13} is 9 or more.
- 20 [0042] R^{14} to R^{20} inclusive can be hydrogen or hydrocarbyl groups, provided at least one of R^{14} to R^{17} and/or R^{18} to R^{20} is a hydrocarbyl group. R^{21} to R^{26} inclusive are hydrocarbyl groups or hydrogen, although hydrocarbyl groups are preferred; and R^{27} can be hydrogen or a hydrocarbyl group, although hydrogen is preferred. The hydrocarbyl group definition for R^{14} to R^{27} inclusive is the same as the definition given for R^{11} , R^{12} and R^{13} .
- 25 [0043] Examples of groups suitable for R^{11} to R^{27} inclusive include isopropyl, n-butyl, isobutyl, amyl, 2-pentenyl, 4-methyl-2-pentyl, 2-ethyl-1-hexyl, 2-ethylhexyl, heptyl, isooctyl, nonyl, decyl, undecyl, dodecenyl, dodecyl, tridecyl, tetradecyl, pentadecyl, hexadecyl, heptadecyl, octadecyl, nonadecyl and eicosyl groups.
- 30 [0044] The epoxy compounds useful for preparing the borate ester of the invention can be represented by the formulae:



or



wherein R^{28} can be an alkyl chain containing 8 to 30, preferably 10 to 26 and even more preferably 12 to 22 carbon atoms; R^{29} can be hydrogen or an alkyl chain containing 1 to 4, preferably 1 to 2 carbon atoms, even more preferably R^{29} being hydrogen; and T can be hydrogen or a halogen, that is, chlorine, bromine, iodine or fluorine or mixtures thereof, although chlorine is preferred. Even more preferably T is hydrogen. When T is a halogen, the epoxy compounds of the invention are epihalohydrin compounds.

[0045] In one embodiment the epoxy compounds of the invention include commercial mixtures of C_{14} - C_{16} epoxides or C_{14} - C_{18} epoxides. In one embodiment, the epoxy compounds of the invention have been purified. Examples of suitable purified epoxy compounds can include 1,2-epoxydecane, 1,2-epoxyundecane, 1,2-epoxydodecane, 1,2-epoxytridecane, 1,2-epoxybutadecane, 1,2-epoxypentadecane, 1,2-epoxyhexadecane, 1,2-epoxyheptadecane, 1,2-epoxyoctadecane, 1,2-epoxynonadecane and 1,2-epoxyicosane. Preferably purified epoxy compounds include 1,2-epoxytetradecane, 1,2-epoxypentadecane, 1,2-epoxyhexadecane, 1,2-epoxyheptadecane, 1,2-epoxyoctadecane; and more preferably 1,2-epoxyhexadecane.

[0046] Another group of compounds described as "epoxy compounds or equivalents" are alcohols and include monohydric alcohols, dihydric alcohols, trihydric alcohols, higher alcohols (that is, alcohols containing 4 or more hydroxy groups) and mixtures thereof, monohydric alcohols being preferred. Typically the alcohol compounds contain 2 to 30, more preferably 4 to 26 and even more preferably 6 to 20

carbon atoms. The alcohol compounds can include glycerol compounds such as glycerol monooleate.

[0047] The borate esters can be prepared by blending the boron compound and the epoxy compound or equivalent and heating them at a suitable temperature, typically 80°C to 250°C, more preferably 90°C to 240°C or 100°C to 230°C, until the desired reaction has occurred. The molar ratio of the boron compound to the epoxy compound or equivalent is typically 4:1 to 1:4, preferably 1:1 to 1:3, and more preferably about 1:2. An inert liquid can be used in performing the reaction. The liquid can be, for instance, toluene, xylene, chlorobenzene, dimethylformamide and mixtures thereof. Water is formed and is typically distilled off during the reaction. Alkaline reagents can be used to catalyze the reaction.

[0048] The borate ester is typically present at 0.01 to 3, preferably 0.03 to 1, and more preferably 0.05 to 0.6 and even more preferably 0.07 to 0.3 weight percent of the lubricating oil composition.

[0049] In one embodiment an optional borate ester may be present in the invention, in addition to the borate ester which has been described above. The optional borate ester is derived from formula (V) except R^{11} , R^{12} and R^{13} are all hydrocarbyl groups containing 1 to 8, preferably 2 to 7 and even more preferably 3 to 6 carbon atoms, provided the total number of carbon atoms in R^{11} , R^{12} and R^{13} is 4 or more, preferably 6 or more and even more preferably 8 or more, and further provided that the optional borate ester contains at least 2 fewer carbon atoms, preferably at least 3 fewer carbon atoms, more preferably at least 4 fewer carbon atoms and even more preferably at least 5 carbons atoms than the borate ester of component (c).

[0050] Suitable examples of the optional borate ester include tripropyl borate, tributyl borate, tripentyl borate, trihexyl borate, triheptyl borate, trioctyl borate, trinonyl borate and tridecyl borate.

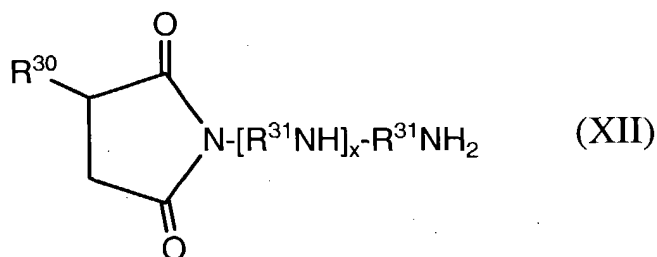
[0051] In one embodiment the optional borate ester is selected from the group consisting tributyl borate, tri-2-ethylhexyl borate and mixtures thereof. In one embodiment the optional borate ester is tributyl borate. In one embodiment the optional borate ester is tri-2-ethylhexyl borate.

[0052] When present, the optional borate ester is typically present at 0 to 5, preferably 0.01 to 3, and more preferably 0.05 to 1.5 and even more preferably 0.1 to 0.7 weight percent of the lubricating oil composition.

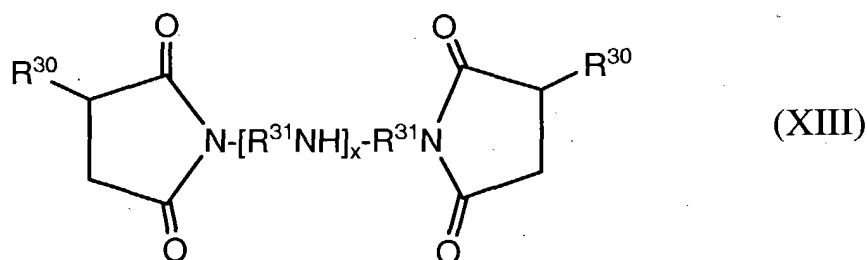
[0053] The total combined amount of borate ester and the optional borate ester is typically 0.01 to 8, preferably 0.04 to 4, and more preferably 0.1 to 2.1 and even more preferably 0.17 to 1 weight percent of the lubricating oil composition.

Borated Dispersant

[0054] The invention further includes a borated dispersant typically derived from N-substituted long chain alkenyl succinimides. The N-substituted long chain alkenyl succinimides have a variety of chemical structures and two typical formulae include:



or



wherein each R^{30} is independently an alkyl group, frequently a polyisobutyl group with a molecular weight of 350 to 5000, preferably 500 to 3000, and R^{31} are alkylene groups, commonly ethylene (C_2H_4) groups. Each R^{30} can also be substituted by additional succinimide functionality and can be attached to the succinimide structures by a variety of linkages. The number of repeat units "x" can be from 1 to 20, preferably 1 to 15 and even more preferably 1 to 10.

[0055] The N-substituted long chain alkenyl succinimides are borated using a variety of agents selected from the group consisting of the various forms of boric acid (including metaboric acid, HBO_2 , orthoboric acid, H_3BO_3 , and

tetraboric acid, $H_2B_4O_7$), boric oxide, boron trioxide, and alkyl borates. These agents are described in more detail above. In one embodiment the borating agent is boric acid which can be used alone or in combination with other borating agents.

5 [0056] The borate dispersant can be prepared by blending the boron compound and the N-substituted long chain alkenyl succinimides and heating them at a suitable temperature, typically $80^{\circ}C$ to $250^{\circ}C$, more preferably $90^{\circ}C$ to $230^{\circ}C$ and even more preferably $100^{\circ}C$ to $210^{\circ}C$, until the desired reaction has occurred. The molar ratio of the boron compounds to the N-substituted long chain
10 alkenyl succinimides is typically 10:1 to 1:4, preferably 4:1 to 1:3, and even more preferably 1:2. An inert liquid can be used in performing the reaction. The liquid can include but are not limited to toluene, xylene, chlorobenzene, dimethylformamide and mixtures thereof.

[0057] The borated dispersant is typically present at 0.03 to 6, preferably 0.06
15 to 3, and more preferably 0.15 to 2 and even more preferably 0.3 to 1.5 wt % of the lubricating oil composition.

Oils of Lubricating Viscosity

[0058] The lubricating oil composition of the present invention can be added to an oil of lubricating viscosity. The oil includes natural and synthetic oils, oil
20 derived from hydrocracking, hydrogenation, hydrofinishing, unrefined, refined and re-refined oils, or mixtures thereof.

[0059] Unrefined oils are those obtained directly from a natural or synthetic source generally without (or with little) further purification treatment.

[0060] Refined oils are similar to the unrefined oils except they have been
25 further treated in one or more purification steps to improve one or more properties. Purification techniques are known in the art and include solvent extraction, secondary distillation, acid or base extraction, filtration, percolation and the like.

[0061] Re-refined oils are also known as reclaimed or reprocessed oils, and
30 are obtained by processes similar to those used to obtain refined oils and often are additionally processed by techniques directed to removal of spent additives and oil breakdown products.

[0062] Natural oils useful in making the inventive lubricants include animal oils, vegetable oils (e.g., castor oil, lard oil), mineral lubricating oils such as liquid petroleum oils and solvent-treated or acid-treated mineral lubricating oils of the paraffinic, naphthenic or mixed paraffinic-naphthenic types and oils
5 derived from coal or shale or mixtures thereof.

[0063] Synthetic lubricating oils are useful and include hydrocarbon oils such as polymerised and interpolymersed olefins (e.g., polybutylenes, polypropylenes, propyleneisobutylene copolymers); poly(1-hexenes), poly(1-octenes), poly(1-decenes), and mixtures thereof; alkyl-benzenes (e.g. dodecylbenzenes, tetradecylbenzenes, dinonylbenzenes, di-(2-ethylhexyl)-benzenes); polyphenyls
10 (e.g., biphenyls, terphenyls, alkylated polyphenyls); alkylated diphenyl ethers and alkylated diphenyl sulphides and the derivatives, analogs and homologs thereof or mixtures thereof.

[0064] Other synthetic lubricating oils include but are not limited to liquid
15 esters of phosphorus-containing acids (e.g., tricresyl phosphate, trioctyl phosphate, and the diethyl ester of decane phosphonic acid), and polymeric tetrahydrofurans. Synthetic oils may be produced by Fischer-Tropsch reactions and typically may be hydroisomerised Fischer-Tropsch hydrocarbons or waxes.

[0065] Oils of lubricating viscosity can also be defined as specified in the
20 American Petroleum Institute (API) Base Oil Interchangeability Guidelines. The five base oil groups are as follows: Group I (sulphur content >0.03 wt %, and/or <90 wt % saturates, viscosity index 80-120); Group II (sulphur content ≤ 0.03 wt %, and ≥ 90 wt % saturates, viscosity index 80-120); Group III (sulphur content ≤ 0.03 wt %, and ≥ 90 wt % saturates, viscosity index ≥ 120); Group IV
25 (all polyalphaolefins (PAOs)); and Group V (all others not included in Groups I, II, III, or IV). The oil of lubricating viscosity is selected from the group consisting of API Group I, II, III, IV, V oil and mixtures thereof. Preferably the oil of lubricating viscosity is an API Group II, III, or IV oil and mixtures thereof.

[0066] The oil of lubricating viscosity is typically present at 78 to 99.9,
30 preferably 89 to 99.8, and more preferably 93.6 to 99.7 and even more preferably 96.3 to 99.3 weight percent of the lubricating oil composition.

Performance Additives

[0067] The lubricating oil composition can include other performance additives selected from the group consisting of metal deactivators, detergents, dispersants, antioxidants, antiwear agents, corrosion inhibitors, antiscuffing agents, extreme pressure agents, foam inhibitors, demulsifiers, friction modifiers, viscosity modifiers, pour point depressants and seal swelling agents. Typically a fully-formulated lubricating oil will contain one or more of these additives.

[0068] The total combined amount of the optional additives present can be 0 to 10, preferably 0.1 to 7, more preferably 0.2 to 5 and even more preferably 1 to 5 weight percent of the lubricating oil composition.

Metal Deactivators

[0069] Metal deactivators can be used to neutralise the catalytic effect of metal for promoting oxidation in lubricating oil. Examples of metal deactivators can include derivatives of benzotriazoles, benzimidazoles, 2-alkyldithio-benzimidazoles, 2-alkyldithiobenzothiazoles, 2-(N,N-dialkyldithiocarbamoyl)-benzothiazoles, 2,5-bis(alkyl-dithio)-1,3,4-thiadiazoles, 2,5-bis(N,N-dialkyldithiocarbamoyl)-1,3,4-thiadiazoles and 2-alkyldithio-5-mercapto thiadiazoles.

[0070] Preferably the metal deactivator is a hydrocarbyl substituted benzotriazole compound. The benzotriazole compounds with hydrocarbyl substitutions include at least one of the following ring positions 1- or 2- or 4- or 5- or 6- or 7-. The hydrocarbyl groups contain 1 to 30, preferably 1 to 15, preferably 1 to 7 carbon atoms, and even more preferably the metal deactivator is 5-methylbenzotriazole (tolyltriazole).

Dispersants

[0071] Dispersants other than the borated dispersants of the invention can also be added. These often known as ashless-type dispersants because, prior to mixing in a lubricating oil composition, they do not contain ash-forming metals, and they do not normally contribute any ash forming metals when added to a lubricant and polymeric dispersants. Ashless type dispersants are characterised by a polar group attached to a relatively high molecular weight hydrocarbon chain. Typical ashless dispersants include N-substituted long chain alkenyl

succinimides. Examples of N-substituted long chain alkenyl succinimides include polyisobutylene succinimide with number average molecular weight 350 to 5000, preferably 500 to 3000. Succinimide dispersants and their preparation are disclosed, for instance in US Patent 4,234,435. The polyisobutylene succinimide can be used alone or in combination with other dispersants.

[0072] In one embodiment the invention further comprises at least one dispersant derived from polyisobutylene, an amine and zinc oxide to form a polyisobutylene succinimide complex with zinc. The polyisobutylene succinimide complex with zinc can be used alone or in combination with other dispersants.

[0073] Another class of ashless dispersant is Mannich bases. Mannich dispersants are the reaction products of alkyl phenols in which the alkyl group contains at least 30 carbon atoms with aldehydes (especially formaldehyde) and amines (especially polyalkylene polyamines).

[0074] Dispersants can also be post-treated conventional method by a reaction with any of a variety of agents. Among these are urea, thiourea, dimercaptiothiadiazoles, carbon disulfide, aldehydes, ketones, carboxylic acids, hydrocarbon-substituted succinic anhydrides, maleic anhydride, nitriles, epoxides, boron compounds, and phosphorus compounds.

Detergents

[0075] Detergents are known and can include neutral or overbased, Newtonian or non-Newtonian, basic salts of alkali, alkaline earth and transition metals with one or more hydrocarbyl sulphonic acid, carboxylic acid, phosphorus acid, mono- and/or di- thiophosphoric acid, alkyl phenol, sulphur coupled alkyl phenol compounds, salixarates, saligenins or mixtures thereof. Commonly used metals include sodium, potassium, calcium, magnesium lithium or mixtures thereof. Most commonly used metals include sodium, magnesium and calcium. Detergents and in particular overbased detergents and their preparation are disclosed in US Patent 3,629,109.

Antiwear Agents

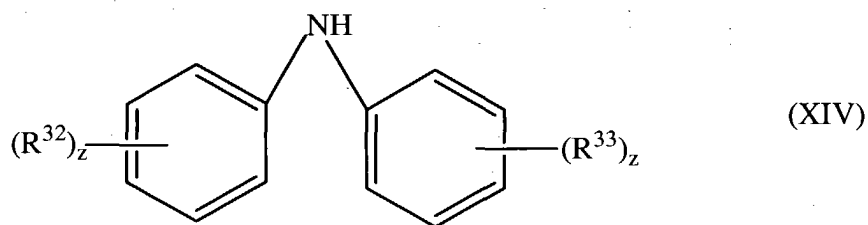
[0076] The lubricating oil composition may additionally contain an antiwear agent. Useful antiwear agents include zinc hydrocarbyl dithiophosphates,

phosphoric acid esters or salt thereof; phosphites; and phosphorus-containing carboxylic esters, ethers, and amides or mixtures thereof. Examples of suitable zinc hydrocarbyl dithiophosphates compounds can include zinc isopropyl methylamyl dithiophosphate, zinc isopropyl isooctyl dithiophosphate, barium di(nonyl)-dithiophosphate, zinc di(cyclohexyl) dithiophosphate, calcium di(hexyl) dithiophosphate, zinc isobutyl isoamyl dithiophosphate, zinc isopropyl n-butyl dithiophosphate, isobutyl primary amyl dithiophosphate, methylamyl dithiophosphate and isopropyl 2-ethylhexyl dithiophosphate.

Antioxidants

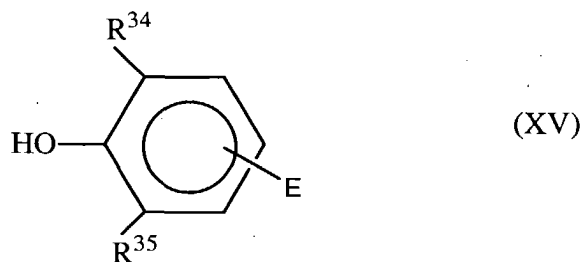
[0077] Antioxidants are known materials and include diphenylamines, hindered phenols, molybdenum dithiocarbamates and sulphurised olefins.

[0078] Diphenylamine antioxidants can be represented by the formula:



wherein R^{32} and R^{33} hydrocarbyl groups, preferably arylalkyl or alkyl groups. The arylalkyl groups contain 6 to 20, preferably 6 to 10 carbons atoms. The alkyl groups can be linear or branched, preferably linear; the alkyl group contains 1 to 24, preferably 2 to 18 and even more preferably 4 to 12 carbon atoms; and z is independently 0, 1, 2, or 3, provided that at least one aromatic ring contains a hydrocarbyl group. Preferred alkylated diphenylamines can include octyl diphenylamine, nonyl diphenylamine, bis-octyl diphenylamine and bis-nonyl diphenylamine.

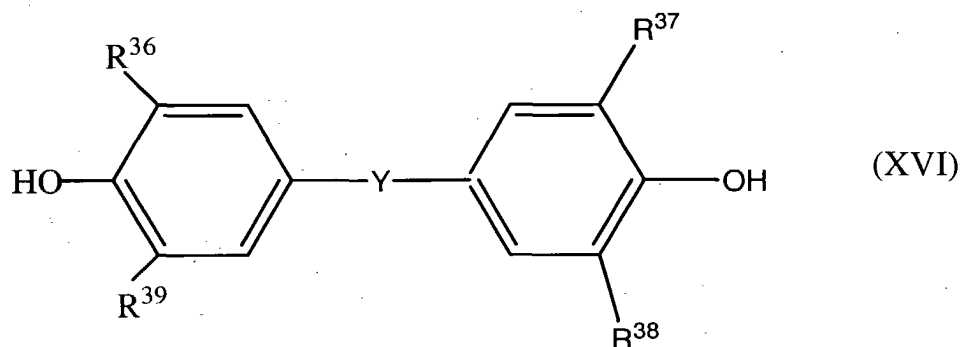
[0079] Sterically hindered phenols can be represented by the formula:



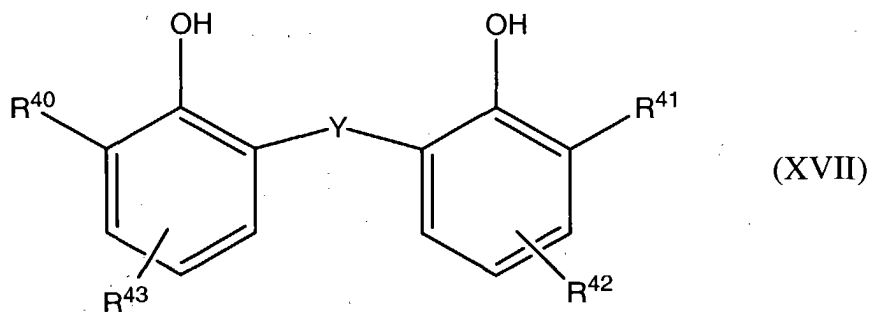
[0080] wherein R^{34} and R^{35} are independently branched or linear alkyl groups containing 1 to 24, preferably 4 to 18, and even more preferably 4 to 12 carbon atoms; and E is hydrogen, hydrocarbyl, a bridging group linking to a second aromatic group or mixtures thereof.

[0081] R^{34} and R^{35} can be either straight or branched chain; branched is preferred. Preferably the phenol is butyl substituted containing two t-butyl groups. When the t-butyl groups occupy the 2,6-positions, the phenol is sterically hindered. Examples of suitable hydrocarbyl groups include 2-ethylhexyl, n-butyl and dodecyl groups. Examples of suitable bridging groups include $-\text{CH}_2-$ (methylene bridge) and $-\text{CH}_2\text{OCH}_2-$ (ether bridge).

[0082] When present, the sterically hindered bridged phenols other than component (a) can be represented by the formulae:

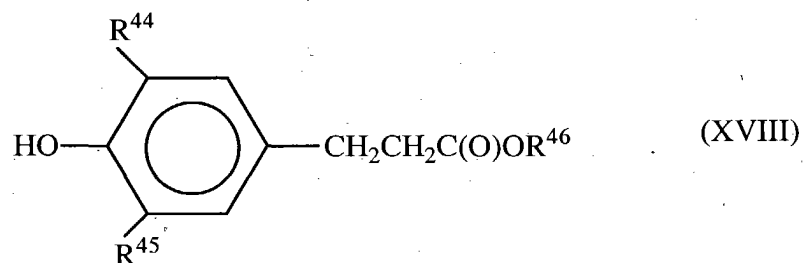


15 or



wherein R^{36} , R^{37} , R^{38} , R^{39} , R^{40} , R^{41} are either straight or branched chain and contain 4 to 18, preferably 4 to 12 carbon atoms. Preferably the phenol is butyl substituted. R^{42} and R^{43} are independently hydrogen or hydrocarbyl; preferably R^{42} and R^{43} are arylalkyl or alkyl groups. The alkyl groups of R^{42} and R^{43} can be linear or branched, linear being preferred. R^{42} and R^{43} are preferably in the para position. The arylalkyl or alkyl groups typically contain 1 to 15, preferably 1 to 10, and more preferably 1 to 5 carbon atoms. The bridging group Y can include $-CH_2-$ (methylene bridge) or $-CH_2OCH_2-$ (ether bridge).

[0083] Examples of methylene-bridged sterically hindered phenols include 4,4'-methylene-bis-(6-tert-butyl o-cresol), 4,4'-methylene-bis-(2-tert-amyl-o-cresol), 2,2'-methylene-bis-(4-methyl-6-tert-butylphenol) and 4,4'-methylene-bis-(2,6-di-tertbutylphenol). In one embodiment, the sterically hindered phenols suitable for the invention can be hindered esters represented by the formula:



wherein R^{44} and R^{45} are straight or branched alkyl groups that can be substituted or unsubstituted, containing 3 to 22, preferably 3 to 18, more preferably 4 to 12 carbon atoms. Specific examples include of alkyl groups di-secondary butyl and tri-tertiary butyl. R^{46} can be hydrocarbyl. Suitable examples include 2-ethylhexyl or n-butyl ester, dodecyl, $-CH_2CH_2COOH$ and mixtures thereof.

[0084] Suitable examples of molybdenum dithiocarboamates include commercial materials sold under the trade names such as Vanlube 822TM and MolyvanTM A from R. T. Vanderbilt Co., Ltd., and Adeka Sakura-LubeTM S-100 and S-165 and S-600 from Asahi Denka Kogyo K. K.

[0085] Examples of suitable olefins that can be sulphurised include propylene, isobutylene, pentene, hexane, heptene, octane, nonene, decene, undecene, dodecene, undecyl, tridecene, tetradecene, pentadecene, hexadecene, heptadecene, octadecene, octadecenene, nonodecene, eicosene or mixtures thereof. In one embodiment, hexadecene, heptadecene, octadecene, octadecenene, nonode-

cene, eicosene or mixtures thereof and their dimers, trimers and tetramers are especially preferred olefins. Alternatively, the olefin can be a Diels-Alder adduct of a diene such as 1,3-butadiene and an unsaturated ester such as butyl (meth) acrylate.

- 5 [0086] Another class of sulphurised olefins include fatty acids and their esters. The fatty acids are often obtained from vegetable oil or animal oil; and typically contain 4 to 22 carbon atoms. Examples of suitable fatty acids and their esters include triglycerides, oleic acid, linoleic acid, palmitoleic acid or mixtures thereof. Often, the fatty acids are obtained from lard oil, tall oil,
10 peanut oil, soybean oil, cottonseed oil, sunflower seed oil or mixtures thereof. In one embodiment fatty acids and mixed with olefins.

Corrosion Inhibitors

- [0087] Corrosion inhibitors can include amine salts of carboxylic acids such as octylamine octanoate, condensation products of dodecenyl succinic acid or
15 anhydride and a fatty acid such as oleic acid with a polyamine, e.g. a polyalkylene polyamine such as triethylenetetramine, and half esters of alkenyl succinic acids in which the alkenyl radical contains 8 to 24 carbon atoms with alcohols such as polyglycols.

Antiscuffing Agents

- 20 [0088] The lubricant may also contain an antiscuffing agent. Antiscuffing agents that decrease adhesive wear are often sulphur containing compounds. Typically the sulphur containing compounds include organic sulphides and polysulphides, such as benzyldisulphide, bis-(chlorobenzyl) disulphide, dibutyl tetrasulphide, di-tertiary butyl polysulphide, sulphurised sperm oil, sulphurised
25 methyl ester of oleic acid, sulphurised alkylphenol, sulphurised dipentene, sulphurised terpene, sulphurised Diels-Alder adducts, alkyl sulphenyl N'N-dialkyl dithiocarbamates, the reaction product of polyamines with polybasic acid esters, chlorobutyl esters of 2,3-dibromopropoxyisobutyric acid, acetoxy-methyl esters of dialkyl dithiocarbamic acid and acyloxyalkyl ethers of xantho-
30 genic acids and mixtures thereof.

Extreme Pressure Agents

[0089] Extreme Pressure (EP) agents that are soluble in the oil include sulphur and chlorosulphur-containing EP agents, chlorinated hydrocarbon EP agents, phosphorus EP agents, and mixtures thereof. Examples of such EP agents include chlorinated wax; organic sulphides and polysulphides such as benzyldisulphide, bis-(chlorobenzyl) disulphide, dibutyl tetrasulphide, sulphurised sperm oil, sulphurised methyl ester of oleic acid, sulphurised alkylphenol, sulphurised dipentene, sulphurised terpene, and sulphurised Diels-Alder adducts; phosphosulphurised hydrocarbons such as the reaction product of phosphorus sulphide with turpentine or methyl oleate; phosphorus esters such as the dihydrocarbon and trihydrocarbon phosphites, *e.g.*, dibutyl phosphite, diheptyl phosphite, dicyclohexyl phosphite, pentylphenyl phosphite; dipentylphenyl phosphite, tridecyl phosphite, distearyl phosphite and polypropylene substituted phenol phosphite; metal thiocarbamates such as zinc dioctyldithiocarbamate and barium heptylphenol diacid; the zinc salts of a phosphorodithioic acid; amine salts of alkyl and dialkylphosphoric acids, including, for example, the amine salt of the reaction product of a dialkyldithiophosphoric acid with propylene oxide; and mixtures thereof.

Foam Inhibitors

[0090] Foam inhibitors are known and can include organic silicones such as polyacetates, dimethyl silicone, polysiloxanes, polyacrylates or mixtures thereof. Examples of foam inhibitors include poly ethyl acrylate, poly 2-ethylhexylacrylate and poly vinyl acetate.

Demulsifiers

[0091] Demulsifiers are known and include derivatives of propylene oxide, ethylene oxide, polyoxyalkylene alcohols, alkyl amines, amino alcohols, diamines and polyamines reacted sequentially with ethylene oxide or substituted ethylene oxides. Examples of demulsifiers include trialkyl phosphates, polyethylene glycols, polyethylene oxides, polypropylene oxides and (ethylene oxide-propylene oxide) polymers.

Pour Point Depressants

[0092] Pour point depressants are known and include esters of maleic anhydride-styrene copolymers, polymethacrylates; polyacrylates; polyacrylamides; condensation products of haloparaffin waxes and aromatic compounds; vinyl
5 carboxylate polymers; and terpolymers of dialkylfumarates, vinyl esters of fatty acids, ethylene-vinyl acetate copolymers, alkyl phenol formaldehyde condensation resins, alkyl vinyl ethers and mixtures thereof.

Friction Modifiers

[0093] Friction modifiers are known and can include fatty amines, esters,
10 especially glycerol esters such as glycerol monooleate, borated glycerol esters, fatty phosphites, fatty acid amides, fatty epoxides, borated fatty epoxides, alkoxyated fatty amines, borated alkoxyated fatty amines, metal salts of fatty acids, sulfurized olefins, fatty imidazolines, condensation products of carboxylic acids and polyalkylene-polyamines, amine salts of alkylphosphoric acids

Viscosity Modifiers

[0094] Viscosity modifiers are known and are typically polymeric materials including styrene-butadiene rubbers, ethylene-propylene copolymers, polyisobutenes, hydrogenated styrene-isoprene polymers, hydrogenated radical isoprene
15 polymers, polymethacrylate acid esters, polyacrylate acid esters, polyalkyl styrenes, alkenyl aryl conjugated diene copolymers, polyolefins, polyalkyl-methacrylates, esters of maleic anhydride-styrene copolymers and mixtures thereof.

[0095] Some polymers can also be described as dispersant viscosity modifiers (often referred to as DVM) because they also exhibit dispersant properties.
25 Typically polymers of this type include polyolefins, for example, ethylene-propylene copolymers that have been functionalized with the reaction product of maleic anhydride and an amine. Another type of polymer is a polymethacrylate functionalised with an amine.

Seal Swelling Agents

[0096] Seal swelling agents are known and are typically esters or low viscosity mineral oils with high naphthenic or aromatic content. Esters can be derived
30 from monobasic and dibasic acids with monoalcohols, or esters of polyols with

monobasic esters. Typically the alcohols contain 8 to 13 carbon atoms. Suitable examples of mineral oil seal swelling agents include adipates, azelates, and sebacates. Examples of suitable mineral oil seal swell agents include Exxon Necton-37™ (FN 1380) and Exxon Mineral Seal Oil™ (FN 3200).

5 Fluidity Modifiers

[0097] Fluidity modifier are known and can include Hydrocal-38 which is a product identified as a refined naphthenic oil, 40 Neutral naphthenic oil and a low molecular weight poly- α -olefin (Ethylflo™ 162).

Process

10 [0098] The invention further provides a process for the preparation of a composition comprising mixing:

- (a) a hydrocarbyl phosphite;
- (b) the condensation product of at least one fatty acid with a polyamine;
- (c) a borate ester;
- 15 (d) a borated dispersant; and
- (e) an oil of lubricating viscosity.

[0099] The mixing conditions are typically 15°C to 130°C, preferably 20°C to 120°C and even more preferably 25°C to 110°C; and for a period of time in the range 30 seconds to 48 hours, preferably 2 minutes to 24 hours, more preferably 5 minutes to 16 hours and even more preferably 10 minutes to 5 hours; and at pressures in the range 86 kPa to 266 kPa (650 mm Hg to 2000 mm Hg), preferably 92 kPa to 200 kPa (690 mm Hg to 1500 mm Hg), and even more preferably 95 kPa to 133 kPa (715 mm Hg to 1000 mm Hg).

20 [0100] The process optionally includes mixing other optional performance additives as described above. The optional performance additives can be added sequentially, separately or as a concentrate.

[0101] If the present invention is in the form of a concentrate the oil of lubricating viscosity is present in an amount less than 78 wt %, preferably less than 65 wt%, more preferably less than 50 wt % and even more preferably less than 45 wt % (which can be combined with additional oil to form, in whole or in part, a finished lubricant), the ratio of each of the above-mentioned components, to diluent oil is typically 80:20 to 10:90 by weight.

Industrial Application

[0102] The compositions of the present invention are useful in a power transmission system, specifically a mechanical power transmission and provide a method for lubricating a transmission system, comprising supplying thereto a lubricant comprising the composition described above. The transmission systems are selected from group consisting of automatic transmissions, manual transmissions, trans-axles, gears and tractor transmissions. Suitable gear applications can include both open and closed systems.

[0103] In one embodiment the compositions of the invention are useful in transmission fluids especially for automatic transmissions. The use of the lubricating oil composition can impart one or more of improved wear resistance, anti-shudder properties, and friction durability.

[0104] The following examples provide an illustration of the invention. These examples are non exhaustive and are not intended to limit the scope of the invention.

EXAMPLES

Example 1

[0105] An oil of lubricating viscosity is prepared by blending 90wt % of API Group III, Motiva Enterprise™ 70N oil, $3.04 \text{ mm}^2\text{s}^{-1}$ (cSt) at 100°C with 10 wt % of API Group II, Neste™ 120N oil, $5.07 \text{ mm}^2\text{s}^{-1}$ (cSt) at 100°C . Added to the oil are (a) 0.33 wt % of the reaction product of boric acid and polyisobutylene succinimide; (b) 0.15 wt % based on the total composition of, the condensation product of a mixture of fatty acids with 16 to 18 carbon atoms with tetraethylene pentamine; (c) 0.2 wt % of a mixture of dialkyl C_{16} to C_{18} hydrogen phosphites; and (d) 0.2 wt % of the reaction product of boric acid with 1,2-epoxyhexadecane. To the resultant mixture, a number of other optional performance additives are added: (a) 2.25 wt % of non-borated dispersants, (b) 2.2 wt % of antioxidants, (c) 0.03 wt% of detergents, (d) 0.04 wt % of metal deactivators, (e) 0.3 wt % of seal swelling agents, (f) 55 ppm of antifoaming agents and (g) 3.1 wt % of diluent oil.

Example 2

[0106] The experimental procedure is identical to the process of Example 1, except 0.16 wt % of the reaction product of boric acid and polyisobutylene succinimide is added.

5 Example 3

[0107] The experimental procedure is identical to the process of Example 1, except that 8.8 wt % of a dispersant viscosity modifier, 0.02 wt % of a pour point depressant and 0.11 wt % of dibutyl hydrogen phosphite are added.

Example 4

10 [0108] The experimental procedure is identical to the process of Example 2, except 0.4 wt % of tributyl borate is added.

Test 1: Ford/Greening Low Speed Friction Test

[0109] Approximately 300 ml of sample is placed in a modified SAE Number 2 machine with a variable speed drive system and the sample is rotated at
15 about 300 rpm for about 30 minutes. For a more detailed description of the test refer to Ford Motor Company MERCON®V specification for Automatic Transmission Fluid, January 1 1999. The recommended maximum wear in this test is 0.076mm. The results obtained are:

Example	Ford/Greening Low Speed Friction Test (mm)
1	0.022
2	0.023
3	0.025
4	0.020

Test 2: Timken Wear Test

20 [0110] This procedure is used to determine the anti-wear properties of automatic transmission fluids by means of the Timken™ Lubricant Tester fitted with a sample holder and filled with about 180 ml of test fluid and operated at 800 rpm with a 4.08 kg (9.0 lb) load at 150°C. A Falex™ test ring is attached to the rotating shaft of the Timken machine. A rectangular test block is held
25 securely within the small-sample adapter and fully immersed in the test lubricant and then brought into contact with the rotating ring. The results obtained are:

Example	Timken Wear Test (mm)
1	0.55
2	0.63
3	0.60
4	0.57

Test 3: Ford Clutch Friction Durability Test

[0111] Approximately 300 ml of sample is placed in a modified SAE Number 2 machine equipped with SD-1777 friction material clutch plate and C8AP-7B442-A separator plate material. The clutch plate and separator plate are engaged and then disengaged 20,000 times. For a more detailed description of the test refer to Ford Motor Company MERCON®V specification for Automatic Transmission Fluid, January 1 1999. The recommended maximum wear in this test is 0.076 mm. The results obtained are:

Example	Ford Clutch Friction Durability Test (mm)
1	0.053
2	0.09
3	0.06
4	0.073

10

[0112] The analysis shows the compositions of the invention produce good results for the various automatic transmission fluid tests. Example 2 in test 3 gives a somewhat high value; it is believed that this value can be significantly reduced by increasing the amount of the borated dispersant.

15

[0113] Each of the documents referred to above is incorporated herein by reference. Except in the Examples, or where otherwise explicitly indicated, all numerical quantities in this description specifying amounts of materials, reaction conditions, molecular weights, number of carbon atoms, and the like, are to be understood as modified by the word "about." Unless otherwise indicated, each chemical or composition referred to herein should be interpreted as being a commercial grade material which may contain the isomers, by-products, derivatives, and other such materials which are normally understood to be present in

20

the commercial grade. However, the amount of each chemical component is presented exclusive of any solvent or diluent oil, which may be customarily present in the commercial material, unless otherwise indicated. It is to be understood that the upper and lower amount, range, and ratio limits set forth
5 herein may be independently combined. Similarly, the ranges and amounts for each element of the invention can be used together with ranges or amounts for any of the other elements. As used herein, the expression "consisting essentially of" permits the inclusion of substances that do not materially affect the basic and novel characteristics of the composition under consideration.